

# An Emerging Science of Environmental Infection Transmission Systems

Jim Koopman, Joe Eisenberg,  
Sheng Li, Ian Spicknall

 UNIVERSITY OF MICHIGAN



The Problem	Progress	Future	Action Decision
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- Environmental actions needed to control emerging human to human infections
  - Barrier precautions, cleaning, decontamination, behavior controls, movement restrictions
  - Detection of environmental threats
- Current MIDAS transmission models
  - Lack both data and theory needed for validation
  - Can't address environmental action decisions
- Contact rates & transmission probabilities in classic models need to be replaced by
  - environmental deposit and pickup models (behavior)
  - fate & transport models
  - cumulative dose-response models

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- Insufficiencies of contact rate models
  - Standard MIDAS approach defines contact as time spent together in a venue
  - Transmission probability estimates per contact usually come from household units
  - No basis to generalize to other units
  - Mode of transmission effects ignored
  - MIDAS models either make arbitrary contact definitions & transmission probability guesses or assume all time in all venues is equally risky
  - Unfeasible to assess venue specific transmission by assessing infection risk given different exposures

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- Integrating Microbial Risk Assessment models into transmission system models is problematic
  - The environment is so diverse with so many factors that strongly affect transmission
  - Ignorance on fate & transport (F&T)
  - Ignorance on how infected humans contaminate environment (H→E)
  - Ignorance on cumulative dose effects (CDR)
  - Integrating F&T, H→E, & CDR models into MIDAS models is computationally unfeasible
  - Theoretical basis for needed simplifications lacking

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- CAMRA is wading into a sea of ignorance
  - The # fomites, surfaces, environmental conditions, and agent characteristics (#F) where F&T studies are needed is huge
  - F&T involves human behaviors (mostly touching) about which we lack data & theory
  - Need to develop methods on small #F
  - #F that can practically be integrated into transmission system models is small --- Need to abstract key sets
  - Key sets of #F can only be worked out in collaborative projects like CAMRA
  - Feedback between models & environmental studies is needed to focus us on the key elements in #F

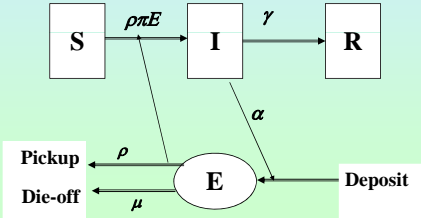
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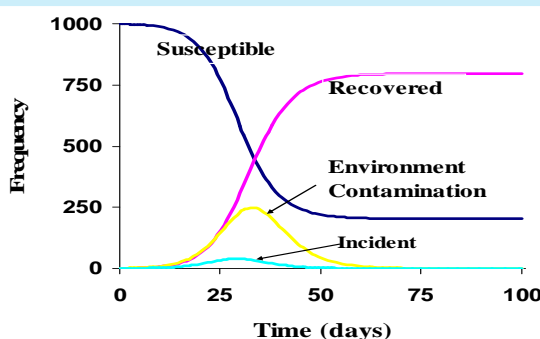
- The theoretical basis and methods for Environmental Infection Transmission System (EITS) models is deficient
  - Behavior of such models unexplored
  - No criteria for abstracting infinite details
  - Methods to bridge vastly different time scales of microbial dynamics, dose-response dynamics and human contact processes are underdeveloped
- The data needs for EITS models are great
  - Cheap detection of environmental contamination from tens of thousands of sites over time is needed
  - More feasible than contact rate & transmission probability data for MIDAS models

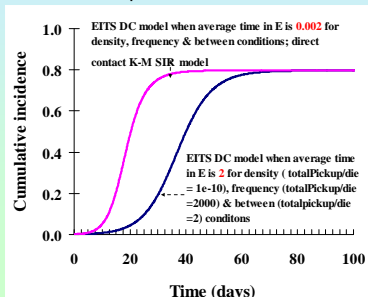
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<ul style="list-style-type: none"> <li>The science needed to address these problems cannot be developed by focusing on the bioterrorist and emerging infection problems presenting the greatest threats <ul style="list-style-type: none"> <li>MRA focus on choosing agents that are good surrogates or markers for great threats does not mesh with developing methods that can take real world data to address infection control decisions</li> <li>Surrogate problems or systems, not surrogate agents, are the first crucial choice</li> <li>Criteria needed to assess feasibility of developing theory and methods relevant to bioterrorist &amp; emerging infection threats using other problems</li> </ul> </li> </ul>			

The Problem	Progress	Future	Action Decision
<ul style="list-style-type: none"> <li>Five Environmental Infection Transmission System (EITS) models or model elements are under study <ul style="list-style-type: none"> <li>Simple stochastic pickup &amp; transport</li> <li>Deterministic one environmental compartment</li> <li>Stochastic one environmental compartment</li> <li>Cumulative dose response models</li> <li>Stochastic transmission system in one venue</li> </ul> </li> <li>A vision for elaborating &amp; integrating these to become realistic, data relevant, models has been developed</li> </ul>			

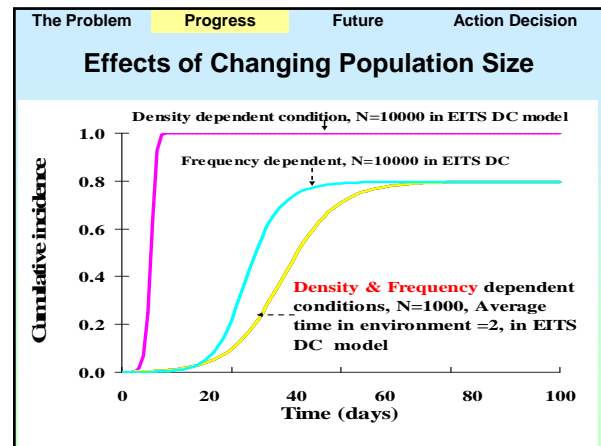
The Problem	Progress	Future	Action Decision
<ul style="list-style-type: none"> <li>Simple stochastic pickup &amp; transport <ul style="list-style-type: none"> <li>System is always far from equilibrium</li> <li>Therefore can't analyze environmental data assuming equilibrium</li> <li>Therefore many thousands of cheap observations of environmental contamination will be needed</li> </ul> </li> </ul>			

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<ul style="list-style-type: none"> <li>Simple stochastic pickup &amp; transport</li> <li>Deterministic one environmental compartment</li> </ul> 			

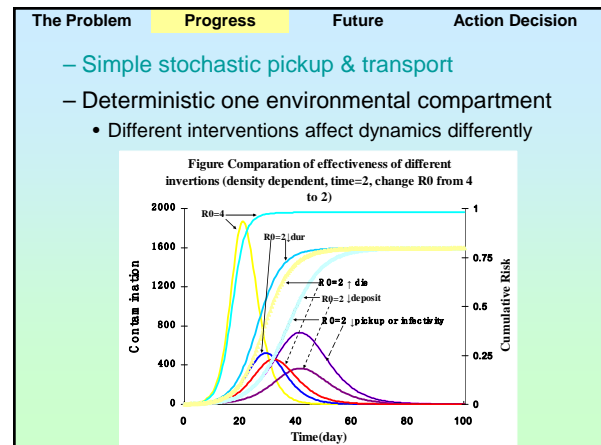
The Problem	Progress	Future	Action Decision
<h3>EITS Dynamics</h3> 			

The Problem	Progress	Future	Action Decision
<ul style="list-style-type: none"> <li>Simple stochastic pickup &amp; transport</li> <li>Deterministic one environmental compartment <ul style="list-style-type: none"> <li>Environmental phase slows transmission dynamics</li> </ul> </li> </ul> 			

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<ul style="list-style-type: none"> <li>– Simple stochastic pickup &amp; transport</li> <li>– Deterministic one environmental compartment <ul style="list-style-type: none"> <li>• Very high pickup from frequently touched surfaces &amp; low die off -&gt; frequency dependent dynamics (Each person exposes a constant # of people regardless of # present so # present does not affect epidemic size)</li> <li>• Low pickup compared to die off (air &amp; infrequently touched surfaces) results in density dependent dynamics (transmission proportional to # present)</li> <li>• Most of world is in between these</li> </ul> </li> </ul>			



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<h3>New Classification of Transmission Modes</h3> <ul style="list-style-type: none"> <li>• Aerosol is always on density dependent end</li> <li>• Droplet-hand-fomite more frequency dependent for frequently touched surfaces or fomites &amp; density dependent for infrequently touched <ul style="list-style-type: none"> <li>– Dose-response and agent survival parameters determine what implies "frequently touched"</li> </ul> </li> <li>• New classification provides a theoretical framework for simplifying models</li> </ul>			



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<ul style="list-style-type: none"> <li>– Simple stochastic pickup &amp; transport</li> <li>– Deterministic one environmental compartment</li> <li>– Stochastic one environmental compartment <ul style="list-style-type: none"> <li>• The environment introduces an additional source of variability that alters intervention effects</li> <li>• Subtle effect</li> <li>• Not yet shown to have practical importance</li> </ul> </li> </ul>			

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<ul style="list-style-type: none"> <li>– Simple stochastic pickup &amp; transport</li> <li>– Deterministic one environmental compartment</li> <li>– Stochastic one environmental compartment</li> <li>– Cumulative dose response model <ul style="list-style-type: none"> <li>• Presented separately by Joe Eisenberg</li> </ul> </li> </ul>			

The Problem	Progress	Future	Action Decision
<ul style="list-style-type: none"> <li>– Simple stochastic pickup &amp; transport</li> <li>– Deterministic one environmental compartment</li> <li>– Stochastic one environmental compartment</li> <li>– Cumulative dose response model</li> <li>– Stochastic transmission system in one venue               <ul style="list-style-type: none"> <li>• Human movement rates and behaviors can alter dominant mode of transmission</li> <li>• Cumulative dose response parameters are big determinant of this effect</li> <li>• Movement &amp; behavior models &amp; data are essential</li> </ul> </li> </ul>			

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<ul style="list-style-type: none"> <li>– Vision for integrating different model forms               <ul style="list-style-type: none"> <li>• Separate model forms can be adapted to each other so they can be used in an inference robustness assessment mode</li> <li>• Models on short time scale (e.g. cumulative dose response or within venue behaviors &amp; movement) can be abstracted to be computationally efficient on longer time scales</li> <li>• CAMRA model analyses provide input theory &amp; data for MIDAS models</li> </ul> </li> </ul>			

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<ul style="list-style-type: none"> <li>• Choice of fomites &amp; conditions to examine in F&amp;T experiments will be explored as stochastic transmission model in one venue is elaborated               <ul style="list-style-type: none"> <li>– Choice based on transmission system role</li> <li>– Different fomites &amp; conditions for different agents (Choose most general, most relevant to bioterrorism, most helpful in building transmission system science)</li> </ul> </li> <li>• Experience in epidemic conditions to be gained with norovirus outbreak studies</li> </ul>			

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<ul style="list-style-type: none"> <li>• Choose better surrogate problem than influenza               <ul style="list-style-type: none"> <li>– Prospective studies can be done any time and are wanted by venues studied</li> <li>– Positive environmental samples for live and total contamination with human agents are common and cheaper to process</li> <li>– Data on infection and colonization of people in venue are readily obtained</li> <li>– Data on who has been where and done what in the venue is available</li> <li>– Extensive prior studies of agents in the environment and natural history of infection in human subjects</li> </ul> </li> <li>• Nosocomial MRSA, <i>Staph aureus</i> &amp; <i>C difficile</i></li> </ul>			

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<ul style="list-style-type: none"> <li>• How will models of nosocomial MRSA, <i>Staph aureus</i> &amp; <i>C difficile</i> inform environmental bioterrorism and emerging infection control?               <ul style="list-style-type: none"> <li>– Develop a needed science that does not exist now</li> <li>– Develop sampling criteria &amp; tools for frequently touched surfaces &amp; fomites, air settling surfaces &amp; infrequently touched fomites</li> <li>– Develop modeling &amp; parameter estimation methods using diverse available data (need problem with lots of data to decide what is possible given limited data)</li> <li>– Learn how to focus environmental sampling using models</li> </ul> </li> </ul>			

<ul style="list-style-type: none"> <li>• Thanks ---- Questions?</li> </ul>			
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